# Smart Soil Monitoring System

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***Abstract- The rapid expansion of population in the digital age has led to a growing demand for efficient and sustainable farming practices. One critical aspect of modern agriculture is soil monitoring, which enables farmers to optimize crop yield, conserve resources, and reduce environmental impact. The proposed system incorporates a network of low-power IoT (Internet of Things) sensors placed in agricultural fields, equipped with various environmental and soil quality sensors. These sensors collect real-time data on soil moisture, temperature, pH levels, and nutrient content. The data is transmitted to a central LoRaWAN gateway, which securely relays it to the cloud for processing and analysis. This abstract presents a Smart Soil Monitoring System that leverages the LoRaWAN (Long-Range Wide Area Network) gateway technology and the Node-RED platform to revolutionize soil management.***

***Indexed Terms- IoT, CLOUD, LoRaWAN, NODERD***

## I. INTRODUCTION

Agriculture plays the major role in economics and survival of people in India. The purpose of this project is to provide embedded based system for soil monitoring and irrigation to reduce the manual monitoring of the field and get the information via cloud server A smart soil monitoring system is a technical tool created to collect, examine, and interpret information on the state of the soil, moisture content, nutrient content, temperature, and other important characteristics. Utilizing IoT (Internet of Things) technologies, this system offers real-time insights into environmental conditions and soil health, enabling more informed and effective farming practices. A smart soil system using IoT (Internet of Things) is an advanced approach to soil management that combines sensor technology, data analysis, and connectivity to optimize soil conditions for optimal plant growth. It leverages real-time data and automation to monitor and control various soil parameters, ensuring plants receive the ideal conditions for their health and productivity. Farmers, researchers, and land managers can make data-driven decisions to maximize crop output, conserve resources, and advance sustainable land management by regularly monitoring and evaluating soil data. Using STM32 microcontrollers and a LoRaWAN gateway, a smart soil monitoring system offers a cutting-edge approach to environmental and precision farming. This system gives farmers, researchers, and land managers access to real-time information about soil conditions, enabling effective resource management and sustainable agricultural practices. LoRaWAN is a long-range, low-power wireless communication technology.

## II. EASE OF USE

### *a. LITERATURE SERVEY*

Works related to a smart soil monitoring system are discussed in this section. This smart parking system uses embedded, IoT, and sensor technology to connect software and hardware to give infrastructure and solutions at a reasonable cost. This system gathers data and displays information in real time using digital means. The smart soil monitoring system uses sensors to provide the user with data on the level of nutrients and soil moisture. In this section, work on a smart soil monitoring system is discussed. This smart soil monitoring system connects the software and hardware to provide infrastructure and a solution at a fair price using sensors, IoT, and LoRa gateway technologies on a TTN server. This technology collects data and displays it digitally in real-time. The smart soil monitoring system's MQTT protocol and LoRa gateway technology give the user access to data on the current state and properties of the soil via the cloud. Smart soil monitoring systems use the cloud, real-time industry-based sensors, and the NODE-RED software application to save data in real-time. Information on the qualities of the soil is transmitted to the user using the Android application. Data-driven agriculture, which is assisted by robotic solutions utilizing artificial intelligence techniques, is the foundation of future sustainable agriculture. IOT and wireless communications are just two of the automation strategies covered in this study. This method makes communication between the gateway and the objects easier by utilizing the MQTT protocol. The usage of artificial intelligence and the Internet of Things for agricultural monitoring can be evaluated using this way. The system connects the irrigation system's control system and actual physical sensors to the cloud. With the development of sensor technology, wireless communications have drawn considerable attention in both the commercial world and in ordinary life.

### *b. PROBLEM DEFINITION*

In the modern world, everything is becoming digitized, and surveillance is becoming automated. In 2022, the agricultural sector will account for 20% of India's GDP, hence it needs to be closely watched in order to enhance yield. We can monitor the soil and take the appropriate action automatically as needed by using the Internet of Things (IoT) to solve this problem. Therefore, the amount of fertilizer recommended was based on plant growth.

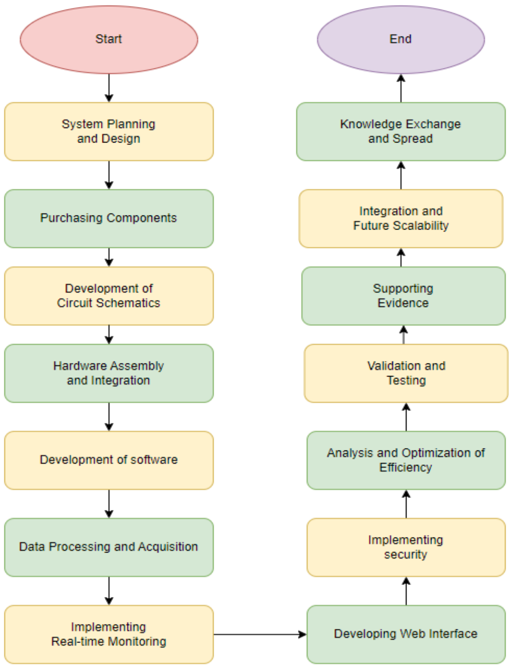
### *c. AIM OF THE PROJECT*

The smart soil monitoring system is an integrated system which is subjected to provide automation in agriculture for managing and monitoring of soil which is inevitable for plant growth. The aim and basic idea is to provide solution to the convectional practice of agriculture, which increase the yield by providing farmers with accurate information on soil moisture, temperature, and nutrient levels.

### *C. HOW SMART SOIL MONITORING SYSTEM WORKS*

Smart soil monitoring system suggests an IoT-Based system that continuously monitor the soil's nutrients level, humidity, pH level via cloud service and display details in web portal using Node-Red portal. We implemented an enclosed smart soil monitoring system that uses NPK sensor, pH sensor, humidity sensor to monitor soil nutrient level, pH level humidity level to take required actions when needed. These sensors are fixed into soil and connected to microcontroller to collect the data. The collect data is stored in cloud for further analysis. The data will be displayed in web portal continuously and necessary steps like humidity level, nutrient level monitoring will be taken automatically. The sensor which is placed in the soil are connected to STM32 microcontroller, this microcontroller enables feasible serial communication which further connected to network through LoRaWAN gateway. A Modbus converter between an STM32 microcontroller and a LoRa gateway serves the purpose of enabling communication and data exchange between devices using the Modbus protocol and the LoRaWAN protocol. LoRaWAN gateways receive data from remote devices (nodes) that are part of the LoRaWAN network. This data, needs to be transported from the gateway to the network server for processing and further actions. The LoRaWAN gateway enables the system to connect the data with cloud. Then by using Nodered platform, the information regarding soil nutrient level, moisture level, pH level are displayed. And also suggestion of nutrients requirement of soil for current plant also displayed in the portal. The MQTT communication protocol is used in LoRaWAN gateway to facilitate proper communication between devices as MQTT uses a publish-subscribe model. In the context of a LoRaWAN gateway, the gateway acts as an MQTT client that "publishes" data to specific "topics." The LoRaWAN network server, which also acts as an MQTT client, "subscribes" to these topics to receive the data. This decoupled approach allows for efficient communication and enables multiple clients (gateways and network servers) to exchange data without directly knowing each other's details. The MQTT protocol plays a pivotal role in enabling seamless communication between LoRaWAN gateways and network servers. It ensures efficient data transport, supports real-time updates, and facilitates remote management and configuration of gateways within a LoRaWAN network.

## III. WORK AND IMPLEMENTATION




Block 1: System Planning and Design

In this preliminary stage, the project is planned, and the needs of the system are established. Based on the project objectives and research findings, it entails defining the hardware components (STM32, NPK Sensor, pH sensor, MQ135 Sensor, LoRa-Gateway, DC motor, Relay), software stack, and overall system design.

Block 2: Purchasing Components
At this stage, all the hardware, sensors, and electronic components are purchased. It ensures that all the supplies required for the project's later stages are available.

Block 3: Development of Circuit Schematics
During this step, a precise schematic diagram of the electronic circuit must be made. It requires designing power supply arrangements as well as specifying component connections and circuit board placements.

Block 4: Hardware Assembly and Integration
The hardware components are assembled in line with the layout of the circuit. During this stage, all of the STM32, NPK Sensor, pH Sensor, MQ135 Sensor, LoRa-Gateway, DC motor, and Relay components must be physically linked.

Block 5: Development of software
The software stack is created, which includes MQTT protocol and Node-Red platform. Because MQTT communication protocol enables communication between modbus convertor and LoRa-Gateway more faster and rielable. Node-red platform used to display data regarding soil in Web interface.

Block 6: Data Processing and Acquisition
The moisture level, pH level, nutrient level data are gathered using microcontroller which is further moved into cloud using TTN(Thinksnetwork) for data processing procedures. Data in clouds are processed displayed in web portal for user reference.

Block 7: Implementing Real-time Monitoring
The system is used with its real-time monitoring features.
Because a web portal can give continuous data refreshes, users can obtain real-time data there.

Block 8: Developing Web Interface
Users can browse and retrieve data from the soil monitoring system using the Node-Red web interface, which was created. interactive features, data presentation, and user authentication development.

Block 9: Implementing security
To protect user data and the system, strong security measures have been included. This covers cyber threat defense, encryption, and authentication.

Block 10: Analysis and Optimization of Efficiency
The system's efficiency and power consumption are evaluated.
Utilizing optimization methods improves energy efficiency.

Block 11: Validation and Testing
To ensure that the system is trustworthy, precise, and functional, it is put through rigorous testing methods. The results of a variety of test scenarios are documented.

Block 12: Supporting Evidence
An extensive amount of documentation is produced, including user guides, technical specifications, project reports, and technical information. For users and

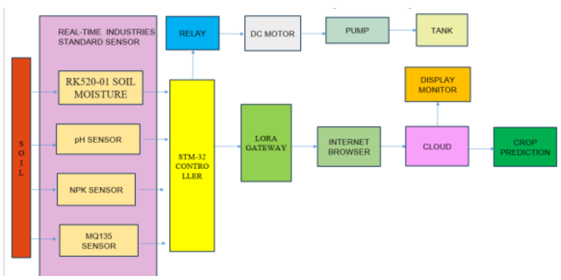
potential developers, this documentation serves as a reference.

Block 13: Integration and Future Scalability
Scalability in the future and integration with emerging technologies are considered. Future upgrades and improvements are supported by the design of the system.

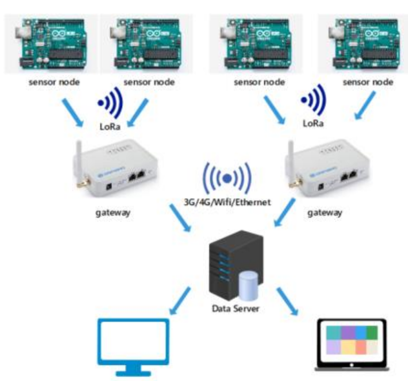
Block 14: Knowledge Exchange and Spread
Knowledge is shared and research findings are projected through presentations, articles, and conversations. The importance of educating the general public about the project's findings is emphasized in this section.

## IV. RESULT AND DISCUSSION

- *BLOCK DIAGRAM*

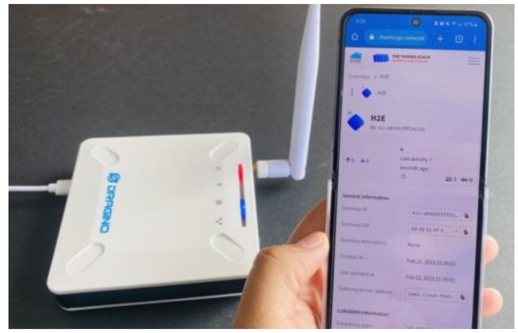



Block Diagram of Soil Monitoring System

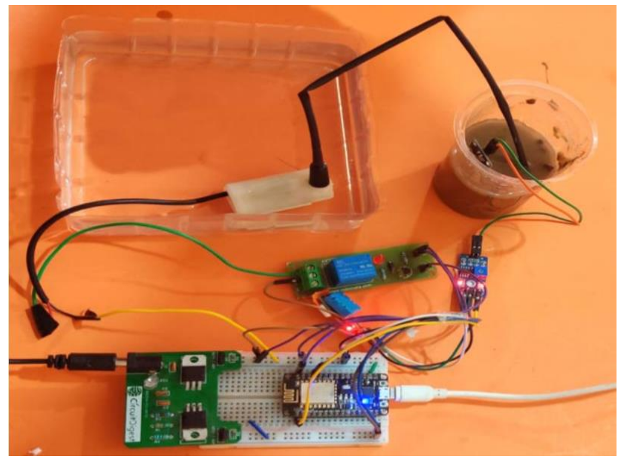



Overall view of whole smart soil monitoring

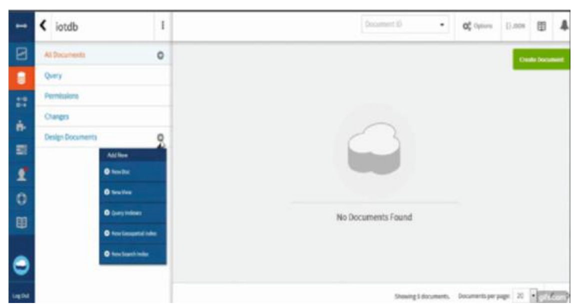
*PICTORIAL REPRESENTATION OF RESULT*



Setting up LoRaWAN gateway and TTN cloud



Setting-up hardware




SQL data store and monitoring


Results of soil analysis using LoRaWAN

Set up NodeRed

## V. APPLICATIONS

- Continuous soil monitoring with IoT sensors provides real-time data on soil moisture, temperature, pH, and nutrient levels. Using data-driven insights, irrigation plans can be streamlined to avoid either being over- or under-watered.
- Fertilizer recommendations based on crop needs and soil nutrient levels guarantee accurate nutrient application.
- Farmers can get advice and real-time information through smartphone apps. enabling quick judgment and remote supervision.
- Through smartphone apps, farmers can obtain real-time information and suggestions. allowing for swift decision-making and remote monitoring.
- Proactive mitigation strategies are made possible by the ability to estimate disease and pest risks thanks to soil and environmental data.
- Data-backed insights assist in determining the best time to use pesticides and other treatments.

*ADVANTAGES:*

- In order to increase crop output, this system provides real-time data on soil moisture level, temperature level, pH level, and nutrient content.
- These technologies provide more precise irrigation, which decreases water waste, by precisely sensing soil moisture levels.
- Labor costs are decreased since this technology automatically monitors and controls soil moisture and nutrient levels.
- Smart soil monitoring systems can reduce fertilizer use when nitrogen levels are sufficient, for example, to maximize resource use and save money.
- These technologies can lessen agriculture's negative environmental effects, such as water pollution and greenhouse gas emissions, by preventing over-irrigation and excessive fertilizer use.

*DISADVANTAGES:*

- Installing smart soil monitoring devices can be costly, particularly for small-scale or resource-constrained farmers.
- Numerous intelligent soil monitoring devices need a constant power source, which might be difficult in rural agricultural settings.
- Data security and privacy issues may arise when sensitive information regarding farming practices and soil conditions is collected and transmitted.
- Farmers may find it difficult to get useful insights from the data without the necessary analysis tools if farmers continuously collect data, which might result in data overload.

## CONCLUSION

The combination of IoT technology with smart soil systems for nutrient, humidity, and pH monitoring has a number of advantages. These technologies promote sensible smart systems and offer real-time data on the soil, which can increase the efficiency of the soil. They offer utility companies and users insightful data that enhances resource management and reduces expenses. As we go through an increasingly energy-conscious society, IoT-based smart soil monitoring systems are poised to play a crucial role in defining a more effective, sustainable, and environmentally friendly future.

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